SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group:	Fuel Turbopumps	Prepared:	F. Cromwell
CIL Item:	B600-07	Approved:	T. Nguyen
Part Number:	RS007601	Approval Date:	11/1/99
Component:	Low Pressure Fuel Turbopump	Change #:	1
FMEA Item:	B600	Directive #:	CCBD ME1-01-5248
Failure Mode:	Structural failure.	Page:	1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
PSN CD 4.1	Immediate loss of turbopump output, overpressurization of aft compartment. Loss of vehicle.	I MF-D2S,A,M,C, ME-D3P,D
	Redundancy Screens: SINGLE POINT FAILURE: N/A	

SSME FMEA/CIL
DESIGN

Component Group:	Fuel Turbopumps	Prepared:	F. Cromwell
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Part Number:	RS007601	Approval Date:	11/1/99
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Design / Document Reference

FAILURE CAUSE: A: Structural failure of weld or parent material of pressure-containing wall.
B. Bellows crack.

THE HOUSING (1) CONSISTS OF 2 MAJOR PARTS. THE TURBINE MANIFOLD (2) AND PUMP VOLUTE (3). THE MANIFOLD IS CONNECTED TO THE PUMP VOLUTE BY PINS (4) AT THE TURBINE DISCHARGE SUPPORT CONE, AND BY BOLTS, SPACERS AND LOCKS (5) AT THE TURBINE END BEARING CARRIER/BELLOWS FLANGE. THE TURBINE MANIFOLD IS A WELDMENT OF CAST, SHEET, BAR AND FORGED INCONEL 718 (6). THIS MATERIAL WAS SELECTED FOR ITS GOOD CASTABILITY, EASE OF WELDING, MECHANICAL PROPERTIES, AND RESISTANCE TO CORROSION AND STRESS CORROSION CRACKING. THE MATERIAL IS SOLUTION TREATED AND AGE HARDENED. THE MANIFOLD INCORPORATES A SINGLE CONVOLUTION BELLOWS WHICH COMPENSATES FOR AXIAL DISPLACEMENT. THE MANIFOLD TORUS AND TURBINE OUTLET ARE COPPER PLATED TO PROTECT THE INCONEL 718 FROM HYDROGEN ENVIRONMENT EMBRITTLEMENT. 321 CRES TUBING IS USED FOR THE DRAIN LINES. 321 CRES WAS SELECTED FOR ITS CRYOGENIC MECHANICAL PROPERITIES, DUCTILITY AND ITS INSENSITIVITY TO HYDROGEN ENVIRONMENT EMBRITTLEMENT (6). THE MATERIAL IS ANNEALED TO IMPROVE MECHANICAL PROPERTIES. THE PUMP VOLUTE IS MANUFACTURED UTILIZING CAST TENS-50 ALUMINUM (6), WHICH WAS SELECTED FOR ITS CASTABILITY, MECHANICAL PROPERTIES, AND RESISTANCE TO HYDROGEN ENVIRONMENT EMBRITTLEMENT. THE CASTING IS HOT ISOSTATICALLY PRESSED TO IMPROVE MECHANICAL PROPERTIES. THE MATERIAL IS SOLUTION TREATED AND AGE HARDENED. THE VOLUTE IS ANODIZED FOR CORROSION PROTECTION. AN ACTIVE CORROSION INHIBITOR IS APPLIED TO THE MANIFOLD AND VOLUTE SURFACES FOR ADDITIONAL CORROSION RESISTANCE (14). THE VOLUTE AND MANIFOLD ARE PROOF PRESSURE TESTED TO VERIFY THEIR STRUCTURAL INTEGRITY (7). THE MANIFOLD AND VOLUTE HAVE BEEN DESIGN VERIFICATION TESTED FOR PRESSURE VS STRESS AND FACTOR OF SAFETY ON BURST (8). THE HIGH AND LOW CYCLE FATIGUE LIFE FOR THE MANIFOLD MEET CEI REQUIREMENTS (9). THE MINIMUM FACTORS OF SAFETY FOR THESE PARTS MEET CEI REQUIREMENTS (10). THE MANIFOLD HOUSING PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE IT IS NOT A FRACTURE CRITICAL PART. EXCEPT FOR VOLUTE HOUSING WHICH WAS CLEARED BY CRITICAL INITIAL FLAW SIZE DETECTABILITY (11). THE FMEA/CIL WELDS ARE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH BY THE WELD ASSESSMENT (12). TABLE B600 LISTS ALL FMEA/CIL WELDS AND IDENTIFIES THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE AND THOSE WELDS IN WHICH THE ROOT SIDE IS NOT ACCESSIBLE FOR INSPECTION. THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE ARE ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (12). RELIEF OF PARTS DURING OVERHAUL IS CONTROLLED BY THE REQUIREMENTS OF THE OVERHAUL SPECIFICATION (13).

(1) RS007632; (2) RS007503; (3) R0019864, (4) RS007631; (5) RD11-1010 RS007613, RS007633; (6) RSS-8577 (7) RL00408, RL00039; (8) RSS-402; (9) RL00532 CP320R00038, (10) RSS-8548, CP320R00038; (11) NASA TASK 17; (12) RSS-9756 (13) RL00531; (14) RS007632, RA1608-010

SSME FMEA/CIL
INSPECTION AND TEST

Component Group:	Fuel Turbopumps	Prepared:	F. Cromwell
CIL Item:	B600-07	Approved:	T. Nguyen
Part Number:	RS007601	Approval Date:	11/1/99
Component:	Low Pressure Fuel Turbopump	Change #:	1
FMEA Item:	B600	Directive #:	CCBD ME3-01-5248
Failure Mode:	Structural failure.	Page:	1 of 3

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	HOUSING ASSEMBLY MANIFOLD VOLUTE		RS007632 RS007603 R0019864
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007603 RB0170-152 RB0170-154 RB0170-099 RS007632 R0019864
		VOLUTE CASTING HOT ISOSTATIC PRESSING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RL00272
		VOLUTE CASTING IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS.	RL00408
		VOLUTE CASTING IS RADIOGRAPHIC INSPECTED PER SPECIFICATION REQUIREMENTS.	RL10003
		A PENETRANT AND HIDDEN SURFACE INSPECTION IS PERFORMED ON THE VOLUTE PRIOR TO AND AFTER PROOF PRESSURE TESTING PER DRAWING AND SPECIFICATION REQUIREMENTS.	R0019864 RL00314 RA0115-116
		MANIFOLD IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS	RL00038
		THE MANIFOLD IS PENETRANT INSPECTED BEFORE COPPER PLATING AND AFTER MACHINING OF COPPER PLATING.	RA0115-116 RS007603
		AN ACTIVE CORROSION INHIBITOR IS APPLIED AND VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS	RS007632 RA1605-010
	HEAT TREAT	MANIFOLD HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENT.	RA0611-020
		VOLUTE HEAT TREAT IS VERIFIED PER DRAWING REQUIREMENTS.	R0019864

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A, B	SURFACE FINISH	MANIFOLD COPPER PLATING IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	RS007603 RA1609-042
		VOLUTE ANODIZING IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RA1609-003
		VOLUTE INTERNAL CAST SURFACE FINISH IS VERIFIED PER DRAWING AND SPECIFICATION REQUIREMENTS.	R0019884 RA0115-007
	WELD INTEGRITY	ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL AS APPLICABLE	RL10011 RAC907-094 RA0115-116 RA0115-006 RA0115-127 RA0115-001
	LPFTP		RS007601
	ASSEMBLY INTEGRITY	THE PUMP SUBASSEMBLIES ARE INSPECTED DURING OVERHAUL PER SPECIFICATION REQUIREMENTS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT AND REPLACEMENT OF USAGE ITEMS AS APPLICABLE, PER OVERHAUL CLASSIFICATION.	RL00531 RA0115-116
		OPERATION/PERFORMANCE IS VERIFIED BY ENGINE HOT-FIRE TESTING AND 2ND E & M TESTS ON INSPECTIONS.	RL00050-04 RL00056-06 RL00055-07 RL00461
		THE LPFTP IS VACUUM DRIED PER SPECIFICATION REQUIREMENTS AFTER GROUND TEST TO ASSIST IN CONTROLLING GALVANIC CORROSION.	RL01061
		THE LPFTP IS INSPECTED FOR EVIDENCE OF GALVANIC CORROSION AT INTERVALS DEFINED BY MAJOR WAIVER.	DAR 2068
		TORQUE CHECKS ARE PERFORMED PRIOR TO EACH FLIGHT.	OMRSD V41BE0.010
		A HELIUM SIGNATURE LEAK TEST IS PERFORMED PRIOR TO EACH LAUNCH.	OMRSD S00000.990

Component Group:	**Fuel Turbopumps**	**Prepared:**	**F. Cromwell**
CIL Item:	**B600-07**	**Approved:**	**T. Nguyen**
Part Number:	**RS007601**	**Approval Date:**	**11/1/99**
Component:	**Low Pressure Fuel Turbopump**	**Change #:**	**1**
FMEA Item:	**B600**	**Directive #:**	**CCBD ME3-01-5248**
Failure Mode:	**Structural failure.**	**Page:**	**3 of 3**

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference*
A, B	ASSEMBLY INTEGRITY	AFT CLOSEOUT INSPECTION IS PERFORMED PRIOR TO EACH FLIGHT.	CMRSD V41BU0.070
		AN EXTERNAL VISUAL INSPECTION IS PERFORMED PRIOR TO EACH FLIGHT.	CMRSD V41BU0.030
		DATA FROM PREVIOUS FLIGHT OR HOT-FIRE IS REVIEWED FOR PROPER TURBOPUMP OPERATION/PERFORMANCE. (LAST TEST)	MSFC PLN 1228

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
Reference: NASA letter SA21/89/308 and Rocketdyne letter 88RC09761

Operational Use: Not Applicable

SSME F A/CIL
LD JOINTS

Component Group: Fuel Turbopumps
CIL Item: B600
Part Number: RS007601
Component: Low Pressure Fuel Turbopump
FMEA Item: B600

Prepared: P. Cromwell
Approved: T. Nguyen
Approval Date: 11/1/99
Change #: 2
Directive #: CCBD ME3-01-5248
Page: 1 of 1

Component	Basic Part Number	Weld Number	Weld Type	Class	Root Side Not Access	Critical Initial Flaw Size Not Detectable HCF	LCF	Comments
MANIFOLD	RS007603	1	EBW	Ia	X			
MANIFOLD	RS007603	2	GTAW	I				
MANIFOLD	RS007603	5,8,10	GTAW	II	X	X		
MANIFOLD	RS007603	9,10	GTAW	II	X			
MANIFOLD	RS007603	13	GTAW	I				
MANIFOLD	RS007603	17	EBW	II	X	X	X	
MANIFOLD	RS007603	18	GTAW	I	X	X	X	

SSME FMEA/CIL

FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

Component Group: Fuel Turbopumps
Item Name: Low Pressure Fuel Turbopump
Item Number: B600
Part Number: RS007601

Prepared: F. Cromwell
Approved: T. Nguyen
Approval Date: 11/1/99
Change #: 3
Directive #: CCBD ME3-01-5248

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. B600-05: RS007605, RS007606; CAUSE A. THE INNER AND OUTER BEARING RINGS ARE EDDY CURRENT INSPECTED PER RA1615-034.	BEARING RINGS RECEIVED FROM SUPPLIER SPLIT BALL BEARING INCORPORATED RECEIVED NO GENERAL EDDY CURRENT INSPECTION.	GENERAL EDDY CURRENT INSPECTION OF RINGS REPLACES TYPE IVC IN PENETRANT INSPECTION IN DETECTING SURFACE FLAWS. USE AS IS RATIONALE: 1 RINGS ARE SUPPLIED BY SPLIT BALL BEARING INCORPORATED RECEIVED 10X VISUAL AND TYPE IVC PENETRANT INSPECTION INSTEAD OF GENERAL EDDY CURRENT INSPECTION. FLAW DETECTABILITY RELIABILITY LEVELS BETWEEN PENETRANT AND GENERAL EDDY CURRENT INSPECTIONS ARE 0.060 AND 0.057 RESPECTIVELY	SEE DAR 2745 FOR VARIANT PART SERIAL NUMBERS
2. B600-10. THE HOUSING INSULATION IS PROTECTED BY A KEVLAR COMPOSITE SURFACE WITH L-T-80 FIRE RETARDANT ALUMINUM TAPE APPLIED TO THE KEVLAR SURFACE	CERTAIN FLIGHT HOUSINGS HAVE NICKEL PLATED INSULATION WITH COPPER PLATED TIE-IN AREAS.	THE BLOCK I AND PHASE II HAVE NICKEL PLATING TO PROTECT THE INSULATION FROM MECHANICAL DAMAGE AND PROVIDE A MOISTURE BARRIER. THE HOUSING IS COPPER PLATED AT THE INSULATION CLOSE-OUT AREAS TO IMPROVE THE NICKEL BOND. THE MINIMUM FACTORS OF SAFETY FOR THE INSULATED HOUSING MEET C.E.I. REQUIREMENTS. DAR 2068 ADDRESSES THE TIME CONSTRAINTS FOR NICKEL PLATED INSULATION WITH COPPER PLATED TIE-IN CONFIGURATIONS.	RS007632-121, -131, -231, -21*
3. B600-05. THE BALLS ARE POSITIONED BY AN FEP COATED ARMALON CAGE. FEP COATING ON CAGES USED TO REDUCE POCKET AND BALL WEAR THUS INCREASING BEARING LIFE.	BLOCK I AND PHASE II PUMPS DO NOT HAVE FEP COATED CAGES.	BLOCK I AND PHASE II CAGES HAVE TEFLON CONTAINED IN THE FIBERGLASS CAGE THAT PROVIDES BEARING LUBRICATION.	RS007605-027 RS007606-007, -025
4. B600-01. BLOCK II NOZZLE ASSEMBLY ALLOWS A MINIMUM OF 12 OF THE 43 NOZZLE PASSAGES TO BE BLOCKED.	BLOCK I PHASE II NOZZLE ASSEMBLY ALLOWS A MINIMUM OF 16 OF THE 43 NOZZLE PASSAGES TO BE BLOCKED	THE BLOCK I PHASE II NOZZLE ASSEMBLY DOES NOT VIOLATE THE REQUIREMENTS OF THE BLOCK II NOZZLE ASSEMBLY. BLOCK I PHASE II NOZZLE MEETS CEI NOZZLE VANE REQUIREMENTS.	R0019780-091
5. B600-02. CAUSE B,C THE SECOND STAGE ROTOR BRAZE JOINT INTEGRITY IS ULTRASONIC INSPECTED PER DRAWING REQUIREMENTS.	CERTAIN SECOND STAGE ROTORS RECEIVED NO ULTRASONIC INSPECTION OF THE BRAZE JOINT.	THE BRAZE JOINTS OF ALL SECOND STAGE ROTORS HAVE RECEIVED A VISUAL AND PENETRANT INSPECTION. ALL PARTS SUSPECTED TO HAVE BRAZE JOINT ANOMALIES HAVE BEEN ADDRESSED.	RS007625-031
6. B600-02. CAUSE D NOZZLE COPPER PLATING ADHESION IS VERIFIED PER DRAWING REQUIREMENTS.	CERTAIN NOZZLES DID NOT RECEIVE A BAKE TEST.	ADHESION BAKE TEST IS NOT REQUIRED FOR NOZZLES WHICH HAVE BEEN PREVIOUSLY HOT FIRE TESTED. THE HOT FIRE ENVIRONMENT ADEQUATELY VERIFIES THE COPPER PLATING ADHESION INTEGRITY.	RS007622-025 R0019783-023
7. B600-02. CAUSE E. THE STATOR COPPER PLATING ADHESION IS VERIFIED PER DRAWING REQUIREMENTS	CERTAIN STATORS DID NOT RECEIVE A BAKE TEST.	ADHESION BAKE TEST IS NOT REQUIRED FOR STATORS WHICH HAVE BEEN PREVIOUSLY HOT FIRE TESTED. THE HOT FIRE ENVIRONMENT ADEQUATELY VERIFIES THE COPPER PLATING ADHESION INTEGRITY	RS007623-031